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Think ahead, but look back

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Building Conservation Journal

OPINION

Think ahead, but look back

H

Historically, architectural form was closely related to local materials. Minimal transportation and the comparatively low energy taken to produce many regionally sourced materials are clearly environmentally beneficial, and these characterise many of our pre-industrial buildings.

Our historic structures are inherently resilient architectural survivors, responding effectively to social, economic and political change. It is commonly said that they were built to last, and do not conform to current, relatively low expectations for durability and notional design life. But all buildings deteriorate, including historic structures. So why are they still with us?

One significant factor is that such buildings are low in risk. In historic terms, construction design, materials and build systems

evolved incrementally. As a result, the severity and impact of defects with these buildings are low, and established technologies enable easy and ongoing rectification of defects. We understand their performance deficiencies but have remedies for them, and the construction sector generally understands the rules of the materials and technologies – although it would still benefit from some investment in training.

Conversely, significant construction innovation – as seen for example during the post-war housing boom – is far more risky, because of its reliance on scientific methods and accelerated testing with limited scope. Complexity leads to uncertainty about the performance of such buildings. New materials and supporting construction technologies brought to market with limited testing pose challenges, especially if the construction sector is not geared up to use them.

Change and risk are largely inseparable. While progress is essential, it would be perverse to ignore the performance of our traditional building stock, which has almost innumerable tonnes of

embodied carbon locked up in its fabric. We know such traditional buildings well and understand their weaknesses; however, we often fail to recognise their importance to society.

It is true that much of our historic built environment is under significant performance strain from climate change, and strategies are needed to enhance its resilience. But we should ask how our innovative construction methods and materials will fare over the next 200 years: will contemporary buildings survive at the same rate as Georgian and Victorian structures?

Much of my own research tries to revisit traditional materials and technologies for fabric repair or contemporary design solutions. These have been shown to have environmental benefits, represent a low risk and are highly durable when used with robust design, detailing and maintenance. Relatively low-carbon materials such as earth, lime and responsibly sourced timber help save carbon through 'fabric first' design. So there is much that can still be learnt from these materials and technologies. ●



Dr Alan Forster is Associate Professor in the School of Energy, Geoscience, Infrastructure and Society at Heriot-Watt University, Edinburgh

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Ivor McElveen discusses the use of lime and the resurgence of hot-mix mortars

Time for a revival

Lime has a long history of use in building construction in the British Isles. Today, it is used more as a plasticiser to improve the workability of cement-mortar mixes and has largely been superseded by Portland cement and gypsum. However, since the 1990s, there has been a revival in its use in construction. Research programmes have proliferated, increasing understanding of its application.

Lime is produced by heating limestone in a kiln until the stone is calcined by releasing carbon dioxide, giving a residue known as quicklime, the basic constituent of all lime mortars. What follows varies by local building tradition, the desired mortar product and modern techniques.

There are several types of lime; the differences mainly depend on the geological origin of the limestone and the proportion of other minerals it contains. The two main types are non-hydraulic lime – also known as pure, fat or air lime – and hydraulic lime, which gets its name from its ability to set underwater. Hydraulic lime can broadly be separated into two groups, namely artificial (HL) and natural hydraulic lime (NHL). HLs are made from a fat lime with a hydraulically reactive component, such as pozzolan, added later. NHLs are made from limestones containing other elements, mainly silica and aluminium, and come in three grades, NHL 2, NHL 3.5 and NHL 5, corresponding roughly to their compressive strengths in N/mm² at 28 days, although these vary depending on the origin of the lime.

Today, hydraulic lime is mainly used in the British Isles, predominantly imported from France, Germany or Portugal. No readily available hydraulic limes are produced in England, neither are there indigenous sources in Scotland, Wales or Ireland – a worrying development when

authentic like-for-like mortars are vital in historic building repairs.

Hot-Lime Mortar Project

In recent years, there has been a revival in the use of indigenous non-hydraulic limes and hot-mix mortars, primarily in a drive to replicate the mortars seen in historic masonry structures. These materials are empirically believed to have greater compatibility with original mortars. Compared to historic mortars, which are invariably a feebly hydraulic hot mix of less than 2N/mm², replacement NHLs were sometimes reaching strengths of over 10N/mm². Mortars made using hydraulic limes tend to be harder, less permeable and not as flexible as those made with non-hydraulic or air limes.

These factors can have long-term adverse consequences for historic buildings, where it is usually preferable for new mortars to be marginally weaker and more permeable than the existing ones to minimise the risk of accelerated deterioration of the masonry fabric. With the accepted conservation principle of like-for-like repairs and seeking as near a replication as possible, hot-mix mortars using indigenous non-hydraulic limes have significant appeal. However, little was known about their use as analytical research has only recently started to gain meaningful attention.

The revival of hot-mix mortars has been stimulated by research undertaken by the Building Limes Forum Ireland, which established the Hot-Lime Mortar (HLM) Project. This involved the transfer of know-how and related research between Scotland and Ireland. Scotland was chosen because it already had more than 20 years' experience in the revival of hot-mix mortars and similar geological, climatic and cultural conditions. Phase I of the project has been completed and phase II has now started.

An HLM Group comprising Historic Environment Scotland, Historic England



▲ Replacing cement render with replica feebly hydraulic hot-mix lime harling and lime wash at 17th-century Craigievar Castle, Alford, Aberdeenshire

and the Heritage Council of Ireland has been set up for phase II, cooperating on an all-islands basis. The intention is that Cadw of Wales and the Historic Environment Division of Northern Ireland will join the group to allow collaboration and innovation, avoid duplication and share procedures, research and information on hot-mix lime mortars.

Hot-mix lime mortars

For the purposes of the project, hot-mix lime mortars have been defined as those where non-hydraulic quicklime, sand and water are mixed together in one operation, often gauged with an NHL or pozzolan, making a ready-to-use mortar. This can be applied 'hot' while the lime is still slaking, or 'cold' after this process.

In the context of traditional construction, this is still the quickest, cheapest and easiest way to make a basic mortar. It is thought that as much as 90% of all mortars used in exterior applications up to the early 20th century were made using hot-mix lime mortar techniques. Therefore, its use today is more likely to replicate the original mortar.

With the modern production of quicklime in kibbled (pea) form, handling it and making mortars is more controllable



and convenient than in the past when it was typically supplied in 'lump' form. The kibbled form of quicklime being relatively dust-free also satisfies important health and safety considerations.

While non-hydraulic quicklime hot-mix mortars are successfully used in suitable climates, they do not necessarily have as fast or predictable a set as NHLs. They will not perform well in areas of extreme exposure or constant dampness, such as the pointing of paving or on the lower levels of bridges. However, with the addition of small quantities of NHL or a pozzolanic additive to the hot mix, their performance can be adapted to suit a wider range of conditions.

For traditional stonemasonry construction and repair, hot-mix lime mortars have been empirically found to perform better than those based on lime putty and NHLs, as is evidenced by their increased uptake. They are generally more workable, can increase productivity, and usually result in cleaner work with no runs of mortar down the face of the wall; they tend not to slump in the joint, which leaves a neater, fuller finish. There is less risk of lime leaching from the mortar, which can lead to a weaker mortar mix at the face of the work.

Practitioners have reported that HLMS allow wet stones to be laid and stabilised without subsequent movement, a common problem with most mortars that are used cold. Very wet sand can

also be used without adversely affecting the final consistency of the mix, owing to the massive absorption of water by the quicklime and loss of some excess moisture due to the heat generated.

Hot-mix lime mortar design

Hot-mix lime mortars are more authentic than imported hydraulic mortars and relatively inexpensive due to the low cost of quicklime and the volume increase that occurs when it has slaked.

When using quicklime as a mortar component, it is important to recognise this volume increase: air limes typically double in volume once slaked, resulting in richer mortar mixes than the 1:3 mixes invariably specified today. Analyses of historic mortar samples have commonly found mixes in the region of two parts lime to three parts aggregate, or even richer. This appears to have been achieved by mixing one part quicklime to three parts aggregate (given the volume increase of quicklime when slaked).

Making hot-mix lime mortars

Practitioners have developed their own preferred methods for batching and mixing hot-mix lime mortars. The end use of the mortar, along with the quantities required, will often dictate the most appropriate method of preparation.

A common way of making bedding and pointing mortars for rubble masonry walls is to mix dry sand and quicklime before



▲ 17th-century St Canice's Steps and Arch, Kilkenny, where masonry repairs and repointing of used feebly hydraulic hot-mix mortars

adding water and mixing thoroughly, adding NHL gauging or a pozzolan last; other methods are used for bricklaying mortars and renders. It is always advisable to seek professional advice and guidance in preparation and application.

Work with all types of mortar requires the user be familiar with Material Safety Data Sheets and prepare an appropriate risk assessment. Personal protection equipment should be worn at all times. The Building Limes Forum Ireland recommends that diphoterine eyewash or equivalent, be kept close to handling, storage, mixing and working areas.

Phase II of the HLM Project

Phase II involves further testing and research using pozzolans. There will be demonstration workshops and information literature, and the forum will encourage discussion and debate.

There is now a more extensive palette from which to select a specific lime mortar for an application, providing authenticity and compatibility with the original materials. ●



Ivor McElveen is a conservation engineer at Ivor McElveen Associates
ivor@ivormcelveenassociates.ie

+info

The HLM Project
<http://bit.ly/1R0f5s2>
Historic Scotland's Hot-mixed Lime Mortars
<http://bit.ly/1JGJo6Y>
www.buildinglimesforumireland.com

Chris McCollum and **Kenny Moore** describe the technical, philosophical and practical stages involved in the conservation of an historic stone obelisk

Needle points

While an obelisk may be an unusual structure for most surveyors, the good practice, assessment techniques, technical issues and philosophical considerations applied to this project should be common to all building conservation work. So when asked by the Follies Trust to assess the damage and suggest conservation options for the Beresford Obelisk at Ballyquin near Limavady in Northern Ireland, the practice Chris McCollum Conservation Surveyors applied standard procedures to this non-standard project to ensure the best results for all concerned.

Visual inspection

The Beresford Obelisk, built in 1840, is a classically designed stone structure with a 34ft needle set on a 12ft rectangular plinth with the remains of four slate plaques, standing on two square steps.

A preliminary inspection determined the main threats to the fabric and made an initial assessment of its condition to confirm it could be conserved, identifying probable repair issues and – critically for the Follies Trust – the likely cost of repair.

A visual assessment from ground level, drawing on the surveyor's experience of working with historic structures, confirmed that the needle and steps were of local Dungiven sandstone, built in battered ashlar and moulded blocks with a core of rubble, and that the base was a mix of stone and brick, now rendered but perhaps originally of dressed stone.

The initial assessment also concluded that there was a slight stoop to the top third of the needle and localised disturbance of the higher stone sections. There was also evidence of structural cracking where vegetation was taking hold in joints in the stone



that had significantly eroded, principally associated with increased frost damage and salt crystallisation. The degree of exposure and the severity of wind-driven rain was a conducive environment for extended periods of fabric saturation.

The stooping is very characteristic of rust jacking in hidden iron cramps, which are used to pin stones together but corrode and expand, pushing up the joints at each level. Corroding metal cramps will expand to around 10 times their original size, and a slender stone structure from this period could be expected to contain many such cramps.

Many individual stones had also failed due to poor bedding techniques, in particular in some of the face bedding to ashlar elevations and edge bedding to corner stones to the needle. How a stone performs in a building depends on many issues, but how its bedding plane is laid is critical. Depending on the function of the stone, the bedding plane can be laid edge, naturally or face, and if incorrectly laid, the stone will fail prematurely.

A number of stones were dislodged and the cement-based render was failing, characteristically pulling the face off the stone below. Finally, much of the original



moulded stone had mechanical damage where it had been keyed to allow the application of cement render. Enough moulding remained to allow the original profiles to be determined.

The conclusion was that the failure at high level had been caused by driving rain increasing the rapidity of frost damage in the mortar joints. Penetrating dampness therefore occurred at depth, corroding the hidden cramps and destabilising the core by leaching the lime matrix. This subsequently meant lower stones became dislodged, while the repair using cement had removed individual stones' faces. At ground level, damage was caused by cattle rubbing the monument's corners and dislodging further stone.

Suggested repair

In broad terms, it was suggested that the repair should involve taking down and rebuilding the top section of the needle, including grouting of core to replace



❶ Second tier of obelisk with original ashlar covered in cement render; the latter had failed, resulting in failure of masonry as well

❷ Replacement of obelisk's apex stone.

❸ The obelisk as conservation work starts and ❹ once complete with the former apex stone placed at the base of the steps

High-level survey

Having been given the go-ahead to proceed to the next stage, the practice undertook a high-level survey using a cherry picker. This allowed individual decayed stones to be inspected at close quarters and meant that the exact condition of the upper reaches of the needle could be ascertained.

This inspection confirmed the visual assessment, with stone delaminating where weathering of weak beds and washing of clay layers in the stone matrix had allowed water ingress and increased weathering. Iron cramps were corroding to the upper reaches of the needle and this was the cause of the stoop.

The apex stone had entirely failed and allowed rainwater to diffuse into the core of the structure from top to bottom, leaching out the lime matrix and allowing stone to become dislodged. The surface of the stones was etched and pitted due to the extreme weather to which the structure is exposed.

Repair options based on repointing, re-dressing, indenting or renewal were possible on a stone-by-stone basis as a result of this inspection technique. It also allowed the needle to be accurately measured and each stone to be renewed and scheduled. At the same time, a full measured survey of the structure was made, including the moulding details to the lower reaches, which were picked up using plumbs and squares.

Philosophical considerations

After the high-level survey the design work began, and detailed scale drawings, specifications and stone schedules were produced. Part of that process was considering the conservation philosophy to be adopted (see also *Building Conservation Journal* May/June, p.28), and in line with good practice the significance of the structure was determined. The structure has both architectural and historical interest, as demonstrated by its listed status, which describes it as a relatively rare object.

The conservation philosophy was decided with the Folies Trust, and drew on the founding manifesto of the Society

for the Protection of Ancient Buildings, the International Council on Monuments and Sites (ICOMOS) Charter (1966), and Australia's ICOMOS Charter (2013), the latter also known as the Burra Charter.

The practice's approach was to repair in an effective and honest manner, doing no more than prudence demanded and avoiding tampering with sound fabric.

The work should consolidate the structure without unnecessary restoration or intervention. Where stone sections had deteriorated but there was enough original fabric to reinstate without conjecture then this was permissible. A combination of traditional and modern conservation techniques would be employed, and the work would seek to eliminate the primary breakdown of the structure. The natural process of general decay would not be arrested.

The tender

The tender package included 1:2 scale drawings of the stone profiles to be renewed, together with detailed drawings of the repairs and rebuilding details. A comprehensive specification linked the drawings, and this was then finished with a stone-by-stone repair schedule that specified the size and bedding of the stone with any repairs required.

The best planned and specified projects will fail if insufficient attention is given to the contractors who are invited to tender. Our built heritage is at risk if contractors with insufficient conservation skills are employed; but perfectly competent local contractors should not be overlooked.

A tender list of contractors was drawn up based on personal observation, matching the size and expertise of the contractors with the size and complexity of the proposed contract. As stone repair was a critical aspect of this project and this trade is usually subtle, the management skills of the main contractor are critical. Likewise, to ensure value for money, the proximity of the contractors to the site is an important element. The number of firms invited to tender should be sufficient to ensure the market is tested, and in this case four contractors were invited to tender.

Traditional repair materials were specified. The original stone was no longer commercially available, so analysis identified a commercially available alternative with a similar chemical make-up, texture and colour to the original. A lime-based mortar was

the lime matrix and fines washed out by driving rain. All stone joints needed to be cleaned out and deep pointed before being repointed using an appropriately designed lime mortar.

The pointing and filleting of ledges should be flush to ensure the shedding of rainwater as efficiently as possible. It was suggested the render to the base be removed to ascertain the condition of the stones beneath, and that if the stone had been clearly dressed and remained in reasonable condition the render should not be reapplied.

The existing slate plaques were fractured but in serviceable condition and could be reset behind replaced stone architraves, which had been removed to facilitate the cement render. The two missing plaques could also be reinstated.

Based on that preliminary inspection, an estimate of £52,400 was given in 2013, excluding VAT, professional fees and new slate plaques.

► specified using hydraulic limes NHL 5 and 3.5, depending on the exposure of the stone elements. New stone to the needle was specified as naturally bedded to help reduce weathering at exposed edges.

The practice favours traditional techniques such as hand pointing and dressing of stone. Stone was fixed using methods that had changed little since the obelisk was originally built, although stainless steel was used in lieu of iron to avoid corrosion and expansion.

New stone was specified for the architraves around plaques, based on an accurate profile lifted off an original. A lead damp-proof course was included below the cap stone as a secondary means of throwing rainwater clear of the wall core at its most vulnerable point.

The work begins

A rigorous programme of site inspections, recording and reporting, testing and site meetings ensured the work proceeded in accordance with the Follies Trust's requirements. The structure was inspected again with the main contractor and the stonemasons, and final marking

of stone undertaken. This saw some additional renewal of stones that had been partially offset by re-dressing and indenting rather than renewal.

The use of test panels to identify a common understanding of materials and finish was adopted to allow work to proceed smoothly. Traditional stonemasonry techniques were specified with consideration to the application and finish of both masonry and mortars. The selection of an appropriate aggregate was a foremost consideration and drying shrinkage was partially controlled by the use of a well-graded sharp aggregate grit. The lime mortar joints were finished with a churn brush in an attempt to leave an open textured surface, which would increase the area of the face to aid the carbonation reaction.

Although it had been predicted, the extent of washing of the core was only fully revealed when the upper section of the needle was taken down and rebuilt. This occurs on exposed masonry where voids develop in the core of the structure, which allows the rainwater to penetrate deep during driving rain.

Where possible, such voids should be located and grouted to replace the missing matrix. This repair technique can be controversial in building conservation as it cannot be reversed; however, in this case it was considered unavoidable given the extremes to which the structure was exposed year-round on all four elevations.

The apex stone was replaced due to its very poor condition, but has been retained at the base of the structure to allow visitors to see the original mason's mark found on its underside. The two missing slate plaques were remade using fragments of the original to create a template for the lettering style.

As the work came to an end, all interventions were documented, with marked-up drawings, photographs, updated elevations and details providing a permanent record of what was done. The final account figure was on budget. ●

Chris McCollum is Director and Kenny Moore is a building surveyor at Chris McCollum Chartered Surveyors
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Improve your conservation skills

Alan Forster explains how you can broaden your experience in the field

Building surveyors are encouraged to look into training, bursaries and scholarships to reconnect traditional crafts with their professional practice. For many years, the Society for the Protection of Ancient Buildings (www.spab.org.uk) has offered the Lethaby Scholarship – the first programme of its kind, which began in 1930. Building surveyors are encouraged to apply for this annual award, which aims to provide in-depth understanding of traditional construction methods, materials and fabric repair, and engender respect for individuals undertaking such highly skilled work. Understanding these areas along with regular maintenance is vital for good conservation.

Between two and four annual bursaries are available, and building surveyors with RICS-accredited degrees and, ideally, a few years spent in practice are encouraged to apply.

The scholarship, which lasts for nine months, includes intensive practical experience alongside expert craftspeople and leading

conservation professionals. Discussions surrounding building conservation philosophy are integral to the scholarship, as this is seen as essential for defensible fabric repair.

The programme allows the scholar to develop their personal interests, with visits to a range of traditional buildings where they will experience such crafts as timber-framing, lime-pointing, masonry and blacksmithery.

Applications must be submitted to catharine@spab.org.uk by 1 December 2016. For more information or to download an application form, please visit <http://bit.ly/1ZN2MWp>.



Dr Alan Forster is Associate Professor in the School of Energy, Geoscience, Infrastructure and Society at Heriot-Watt University, Edinburgh



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UPDATE

Heritage Update is compiled by Henry Russell OBE FRICS, School of Real Estate and Planning, University of Reading and Chair of the Heritage Alliance's Spatial Planning Advocacy Group
h.j.g.russell@reading.ac.uk

Culture white paper

The Culture White Paper published by the government in March has been welcomed by the sector for prioritising heritage. It makes some important commitments as well, including continued funding for the Heritage Lottery Fund's Skills for the Future programme, which offers a range of work-based training designed to provide the expertise essential to the historic environment.

Historic England is charged with identifying how it can offer more support to local authorities; to work with them on national and local heritage records so that communities and developers have easy



access to these; and to work with other heritage organisations to develop the sector's international commercial offer.

The government has also provided £3m for the Architectural Heritage Fund to advise communities on how to make the best use of historic buildings, including through ownership.



Housing and Planning Bill

While the bill proceeds through Parliament, technical consultation by the Department for Communities and Local Government on how the provisions of the legislation will be implemented closed on 15 April.

The department sought views on a range of provisions in the bill, including the following:

- planning permission in principle
- register of brownfield sites suitable for development
- small sites register
- local plans and neighbourhood planning
- broadening the planning performance regime
- testing competition in the processing of planning applications
- changes to planning application fees.

● **Implementation of planning changes: technical consultation**
<http://bit.ly/1QnA1cD>



Church quinquennial inspections

The Church of England plans to introduce changes to the quinquennial inspection system in the wake of the Church Buildings Review chaired by the Bishop of Worcester and the faculty simplification programme, which has streamlined application procedures for works. The enabling legislation for the proposed reform will be submitted to the General Synod in July, with the substance and detail set out after this in regulations and statutory guidance following detailed consultation with all dioceses and other interested parties.

Heritage research

The seven UK research councils support academic research through funding and grants, and have published their delivery plans for 2016–20. Heritage falls under the remit of the Arts and Humanities Research Council (AHRC), and is identified as a key strand as it has the potential to: "...secure the UK's place at the cutting edge of this dynamic multidisciplinary field. There is clear potential to connect Heritage with the new Global Challenges Research Fund ... with regard, for example, to the protection of cultural heritage from the consequences of conflict (Palmyra provides a salutary reminder of the potential for new digital technologies to record archaeological treasures), the sustainability of heritage in the face of urbanisation and climate change, or the role of heritage in helping societies confront difficult and divided pasts."

● **AHRC Delivery Plan 2016/17–2019/20** (<http://bit.ly/trGOHAK>)

Apply now for certification

The new RICS Historic Building Professional Certification recognises those with experience in managing the performance of built heritage.

Application requires submission of five case studies, detailing issues addressed and outcomes achieved. Assessment is by interview, focusing on conservation philosophy across the individual's discipline.

The next deadline for applications is 29 July 2016.

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